

DOE/ID-11099
Revision 0
Project No. 23361
September 2003



U.S. Department of Energy
Idaho Operations Office

First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory



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Engineering and Environmental Laboratory**

September 2003

**Prepared for the
U.S. Department of Energy
Idaho Operations Office**

ABSTRACT

The remedy for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory included consolidating and capping contaminated sediments, removing contaminated materials, institutional controls, and monitoring the decrease of contamination in groundwater caused by radioactive decay, dispersion, and natural attenuation. This five-year review found that the selected remedies and institutional controls were implemented in accordance with the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* (published December 1997) and as modified by the *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (published May 2000).

The remedies at Operable Unit 2-13 are performing as expected and are continuing to provide protection of human health and the environment. Potential short-term threats are being addressed through institutional controls. Soil cover remedies constructed under Operable Unit 2-13 are being maintained properly and inspected in accordance with the appropriate requirements. In the long term, the remedies are expected to be protective when groundwater cleanup goals are achieved through monitored natural attenuation. Trends for contaminants of concern in aquifer water either are currently below the maximum concentration levels or are projected to be below the maximum concentration levels in 2012. Several issues have been identified relating to increasing trends of contaminants in the deep-perched water zone. These trends appear to be related to new or undiscovered releases or surface sources of water that have occurred since the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* was signed. New evaluations are warranted to determine the cause and sources of these increasing contaminant trends in the perched water. In addition, the new mission for the Idaho National Engineering and Environmental Laboratory, which will keep Test Reactor Area operational for at least another 20 years, will cause perched water to persist beneath the Test Reactor Area beyond the modeling assumptions used in the risk assessment for the *Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12, Idaho National Engineering Laboratory, Idaho Falls, Idaho*. The impact of contaminants moving with perched water to the aquifer will need to be reevaluated.

SUMMARY

The remedy for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory included consolidating and capping contaminated sediments, removing contaminated materials, institutional controls, and monitoring the decrease of contamination in groundwater caused by radioactive decay, dispersion, and natural attenuation. This 5-year review found that the selected remedies and institutional controls were implemented in accordance with the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* (published December 1997) and as modified by the *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (published May 2000).

The remedies at Operable Unit 2-13 are performing as expected and are continuing to provide protection of human health and the environment. Potential short-term threats are being addressed through institutional controls. Soil cover remedies constructed under Operable Unit 2-13 are being maintained properly and inspected in accordance with the appropriate requirements. In the long term, the remedies are expected to be protective when groundwater cleanup goals are achieved through monitored natural attenuation. Trends for contaminants of concern in aquifer water either are currently below the maximum concentration levels or are projected to be below the maximum concentration levels in 2012. Several issues have been identified relating to increasing trends of contaminants in the deep-perched water zone. These trends appear to be related to new or undiscovered releases or surface sources of water that have occurred since the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* was signed. New evaluations are warranted to determine the cause and sources of these increasing contaminant trends in the perched water. In addition, the new mission for the Idaho National Engineering and Environmental Laboratory, which will keep Test Reactor Area operational for at least another 20 years, will cause perched water to persist beneath the Test Reactor Area beyond the modeling assumptions used in the risk assessment for the *Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12, Idaho National Engineering Laboratory, Idaho Falls, Idaho*. The impact of contaminants moving with perched water to the aquifer will need to be reevaluated.

Groundwater modeling completed before the signing of the *Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12, National Engineering Laboratory, Idaho Falls, Idaho* predicted the dissipation of perched water within 6 years following cessation of discharge to all disposal ponds. The modeling also predicted that tritium levels within the aquifer would drop below the maximum contaminant level (20,000 pCi/L) by 2004, chromium levels would meet or drop below the maximum contaminant level (0.1 mg/L) by 2016, and cadmium would drop below its maximum contaminant level (0.005 mg/L) by 2029. It is important to note the following: (1) perched water has remained and will remain beneath the Test Reactor Area as long as the discharge of significant quantities of water continues to the Cold Waste Pond; (2) predicted trends made by the pre-Record of Decision model are for aquifer concentrations only (not perched water); (3) the pre-Record of Decision model

assumed cessation of discharge to the Cold Waste Pond in 2007 with closure of the Test Reactor Area facility.

The deep-perched water zone is monitored by 28 wells that are sampled routinely for contaminant-of-concern concentrations. Based on the review and trending of groundwater contaminants performed for this 5-year review, the summary of the data is as follows:

- Am-241, As, Be, Cd, Cs-137, Cr, Co-60, F, Pb, Mn, Sr-90, tritium, and Hg are the identified contaminants of concern for the Snake River Plain Aquifer beneath the Test Reactor Area. With the exception of Cr, H-3, Co-60 and Sr-90, it was determined that the other eight contaminants of concern have little impact on the perched water or the aquifer.
- Trends in deep-perched water wells over the past 5 years. Exceptions to the general decreasing trend include increasing or flat activities of Sr-90 in Wells PW-12, USGS-054, USGS-055, and USGS-070 as well as a recent increase of Co-60 in Well PW-12.
- The primary contaminants of concern identified for the Snake River Plain Aquifer are Cr and H-3. The other 10 identified contaminants of concern have low concentrations or are at nondetect levels and are considered to have no significant impact to the Snake River Plain Aquifer.
- Measured concentrations of chromium levels in the aquifer are decreasing and are expected to decline below the maximum contaminant level by 2012 for all wells.
- Tritium levels in all aquifer wells are below the maximum contaminant level and are expected to continue to decrease due to radioactive decay and dilution.
- Based on the trend data for Sr-90 in the Snake River Plain Aquifer, it is expected to diminish and reach predicted concentrations, made by the pre-Record of Decision model, in the year 2008.

The implemented remedies from the ***Final Record of Decision, Test Reactor Area, Operable Unit 2-13***, have been determined to be protective of human health and the environment. Potential short-term threats are being addressed through institutional controls. Long-term protectiveness of human health and the environment under the Record of Decision was determined based upon concentrations predicted in the aquifer (not in perched water). Trends for contaminants of concern measured in the aquifer during this first 5-year review period either are currently below the maximum contaminant levels or are projected to be below the maximum contaminant levels in 2012. Thus, the chromium concentrations in all wells will be below the maximum contaminant level 4 years in advance of the pre-Record of Decision model that predicted the concentration of chromium to reach the maximum contaminant level by 2016. Issues identified in this 5-year review related to perched water are not expected to affect the protectiveness of the selected remedies. Ongoing discussions with

the Agencies will define activities to fully evaluate the perched water conditions and long-term impacts on the aquifer. Long-term protectiveness will be satisfied under the selected remedy when groundwater cleanup goals are achieved (estimated to occur in the year 2012) and the long-term impacts on the aquifer from the perched water conditions have been fully evaluated by the agencies.

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ACRONYMS

bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWP	Cold Waste Pond
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EPA	U.S. Environmental Protection Agency
EVS	Environmental Visualization System
IDL	instrument detection limit
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
MCL	maximum contaminant level
OU	operable unit
PCB	polychlorinated biphenyl
ppm	parts per million
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
SRPA	Snake River Plain Aquifer
TRA	Test Reactor Area
USC	United States Code
USGS	United States Geological Survey

First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory

1. INTRODUCTION

Fifty-five release sites, in total, were evaluated in the *Comprehensive Remedial Investigation/Feasibility Study for Test Reactor Area Operable Unit 2-13 at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 1997a). Eight of these sites were identified as having actual or threatened releases of hazardous substances that could present a possible threat to human health and the environment. The remaining 47 sites were determined to not represent an unacceptable risk to human health and the environment; therefore, these sites required no further action. The *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (DOE-ID 2000a) identified seven of the 47 sites, which were listed previously as no action sites, as requiring specific institutional controls to prevent a possible threat to human health and the environment. Detailed descriptions of the contamination, the response taken, and the risk basis for the eight sites identified in the *Comprehensive Remedial Investigation/Feasibility Study for Test Reactor Area* (DOE-ID 1997a) and the seven sites added by the *Explanation of Significant Differences* (DOE-ID 2000a) are given in Appendix E. The remaining 40 “no action” site determinations were based on the land use assumption made in the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* (DOE-ID 1997b). Figure 1 is a detailed map of the Test Reactor Area.

2. PURPOSE

The purpose of the 5-year remedy review is to evaluate and determine whether the remedies prescribed by the Record of Decision (DOE-ID 1997b) are expected to remain protective of human health and safety and the environment. In general, Five-Year Review Reports document the methods, findings, and conclusions from monitoring and inspections required by a Record of Decision. In addition, Five-Year Review Reports identify issues found during the review and list recommendations to address the issues.

The U.S. Department of Energy (DOE) is preparing this Five-Year Review Report pursuant to Section 121 of the “Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund)” (42 USC § 9601 et seq.) and 40 *Code of Federal Regulations* (CFR) 300, “National Oil and Hazardous Substances Pollution Contingency Plan.”

The DOE has the duty and authority by law to conduct 5-year reviews at the Idaho National Engineering and Environmental Laboratory (INEEL), since this was delegated to DOE for the INEEL, under Section 2(d) of Executive Order 12580, pursuant to the President’s authority to delegate, conferred by Section 115 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.). Furthermore, the “National Oil and Hazardous Substances Pollution Contingency Plan,” as promulgated in the *Code of Federal Regulations*, recognizes by 40 CFR 300.5 that DOE will be the lead agency for the INEEL with regard to conducting 5-year reviews. While the responsibility and authority for conducting 5-year reviews lies with the DOE, the U.S. Environmental Protection Agency (EPA) retains authority over whether the 5-year review adequately addresses the protectiveness of remedies. The *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991a) specifies that the EPA may review response actions and, with consultation from the Idaho Department of Environmental Quality (IDEQ), determine whether additional action is required by DOE. Final authority and acceptance of this review are at the EPA’s discretion.

This is the first 5-year review for the Test Reactor Area (TRA) Operable Unit (OU) 2-13 site. The triggering action for this statutory review is the signature of the Record of Decision (DOE-ID 1997b) on December 22, 1997. The 5-year review is required because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted access to the site. The U.S. Department of Energy Idaho Operations Office (DOE-ID) conducted this 5-year review of the implemented remedy at the INEEL TRA, OU 2-13 from June through December 2002 and generated an initial draft report. This report is the second draft and includes monitoring data through March 2003.

3. SITE CHRONOLOGY

The TRA was established in the early 1950s in the southwestern portion of what was then the National Reactor Testing Station—now the INEEL—for studying radiation effects on materials, fuels, and equipment. The TRA was designated as Waste Area Group 2, under the Federal Facility Agreement and Consent Order (DOE-ID 1991a).

In December 1991, the *Declaration for the Warm Waste Pond at the Test Reactor Area at the Idaho National Engineering Laboratory—Declaration of the Record of Decision* (DOE-ID 1991b) was signed. Remediation directed by this Record of Decision was carried out in 1992. The *Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12, Idaho National Engineering Laboratory, Idaho Falls, Idaho* (DOE-ID 1992) was signed in December 1992. Monitoring plans were developed in accordance with the Record of Decision.

In February 1997, the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a) was completed. Fifty-five sites were evaluated for contaminant concentrations, and data were provided to warrant remedial actions at eight of these sites where remaining contaminant concentrations presented unacceptable risks to human health and safety or the environment. Remedial action was recommended for four sites, and limited action was recommended for the other four sites in the Record of Decision (DOE-ID 1997b). The OU 2-13 Record of Decision is inclusive of the Warm Waste Pond (OU 2-10) and OU 2-12 Records of Decision (DOE-ID 1991b, 1992) and all TRA operable units. Remedial actions were initiated at these sites in 1999 and completed in 2000. The objectives, a brief description of the actions completed, and technical evaluations of these remedial actions are discussed in this Five-Year Review Report.

Based on the results of the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a), the remaining 47 sites were identified as no action sites, posing no acceptable risks to human health and safety and the environment. For seven of the 47 sites, determinations were based on assumptions that no changes would occur to either land use or exposure routes. As specified in the OU 2-13 Record of Decision (DOE-ID 1997b), land use will be reviewed for these seven sites. The Explanation of Significant Differences (DOE-ID 2000a) required that these seven sites have institutional controls. A brief description and an evaluation of the institutional controls of these seven sites and the eight other sites, and their effectiveness, are discussed here. Table 1 shows the chronology of site events.

Table 1. Chronology of site events.

Event	Date
Identification of potential hazards on the INEEL during an initial installation assessment	January 1986
<i>Consent Order and Compliance Agreement</i>	July 28, 1986
National Priorities List listing	November 15, 1989
<i>Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory</i> signed	December 9, 1991
<i>Declaration for the Warm Waste Pond at the Test Reactor Area at the Idaho National Engineering Laboratory — Declaration of the Record of Decision</i> signed	December 1991
Operable Unit 2-10 removal action of windblown contamination at the Warm Waste Pond	1992
<i>Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12</i> signed	December 1992
<i>Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13</i>	March 1993
Operable Unit 2-10 Warm Waste Pond interim action complete	December 1993
Operable Unit 2-04 Non-Time-Critical Removal Action complete at TRA-34	1995/1996
<i>Post Record of Decision Monitoring Plan for the Test Reactor Area Perched Water System Operable Unit 2-12</i> complete	August 1996
Three-year statutory review of the deep-perched water system complete	August 1996
<i>Comprehensive Remedial Investigation/Feasibility Study for the Test Reactor Area Operable Unit 2-13 at the Idaho National Engineering and Environmental Laboratory</i> complete	February 1997
<i>Final Record of Decision, Test Reactor Area, Operable Unit 2-13</i> signed	December 22, 1997
<i>Groundwater Monitoring Plan for the Test Reactor Area Operable Unit 2-13</i> complete	July 1998, revised 2003
<i>Comprehensive Remedial Design/Remedial Action Work Plan for the Test Reactor Area, Operable Unit 2-13</i> complete	September 21, 1998
Five-year statutory review of the Warm Waste Pond interim action complete	September 1998
Actual remedial action start	March 8, 1999
Comprehensive Operable Unit 2-13 remedial action complete	December 1999
<i>Operations and Maintenance Plan for the Final Selected Remedies and Institutional Controls at Test Reactor Area, Operable Unit 2-13</i> complete	March 2000
<i>Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13</i> covering site-specific institutional controls	May 2000
DOE-ID = U.S. Department of Energy Idaho Operations Office INEEL = Idaho National Engineering and Environmental Laboratory TRA = Test Reactor Area	

4. BACKGROUND

4.1 Physical Site Characteristics

The INEEL is a government-owned contractor-operated facility, which is managed by the DOE-ID. The INEEL's eastern boundary is located 32 mi west of Idaho Falls, Idaho, and occupies 890 mi² of the Eastern Snake River Plain. Classified as semiarid, the area receives an average of 8.7 in. of precipitation annually. The TRA is located in the INEEL's southwestern portion (Figure 2), approximately one mile north of the Big Lost River, outside of the 100-year flood zone.

The TRA rests on the Big Lost River's alluvial plain. Alluvial deposits range from 30 to 75 ft thick and consist of coarse gravels and sands with some clay layers. A thick sequence (>1,650 ft) of basalt and interbedded sediments is located beneath the alluvium. Basalts make up approximately 70% of the subsurface stratigraphy. The shallow, sedimentary interbeds vary in thickness from 3 to 43 ft and are often laterally discontinuous. Recent deep coring encountered two thick, apparently continuous, interbeds from 1,221.6 to 1,251.8 ft below ground surface (bgs) and 1,290.9 to 1,506.5 ft bgs (INEEL 2003).

4.2 Land and Resource Use

The TRA was established in the 1950s for studying radiation effects on materials, fuels, and equipment. Three reactors have been used at the TRA: (1) the Advanced Test Reactor, (2) the Engineering Test Reactor, and (3) the Materials Test Reactor. Currently, only the Advanced Test Reactor is operating. Current activities generate low volumes of chemical and low-level radioactive waste; however, historically, the facilities have generated these types of waste on a larger scale and have been the site of occasional accidental releases of polychlorinated biphenyls (PCBs), diesel, and other chemical waste.

The current land use for the surrounding area is restricted, primarily by an INEEL buffer zone, with seasonally permitted grazing within 3.5 mi west and north of the TRA (Figure 3). Land use for the next 100 years is expected to remain under government control. No residential development will be allowed within the INEEL boundaries, and no major private developments, residential or nonresidential, are expected on public lands adjacent to the INEEL for the next 100 years.

Three subsurface water bodies are located beneath the TRA. The lowermost body, located approximately 450 ft bgs, is the Snake River Plain Aquifer (SRPA). The SRPA was designated as a sole-source aquifer under the "Safe Drinking Water Act" (42 USC § 300f to 300j-26) on October 7, 1991. The SRPA provides potable water for use at the INEEL, as well as for use at private and municipal wells outside INEEL borders. Two perched water bodies, above the aquifer, are caused by water discharge to unlined ponds at TRA. The upper-perched water body is located approximately 50 ft bgs. The lower perched water body is located between 140 to 200 ft bgs. Perched water is not utilized for any purpose. Institutional controls continue to restrict access to all water beneath land surface at the TRA.

4.3 History of Contamination, Initial Response, and Basis for Action

See Appendix E for a description of the history of contamination, initial response, and the basis for action for each of the individual sites.

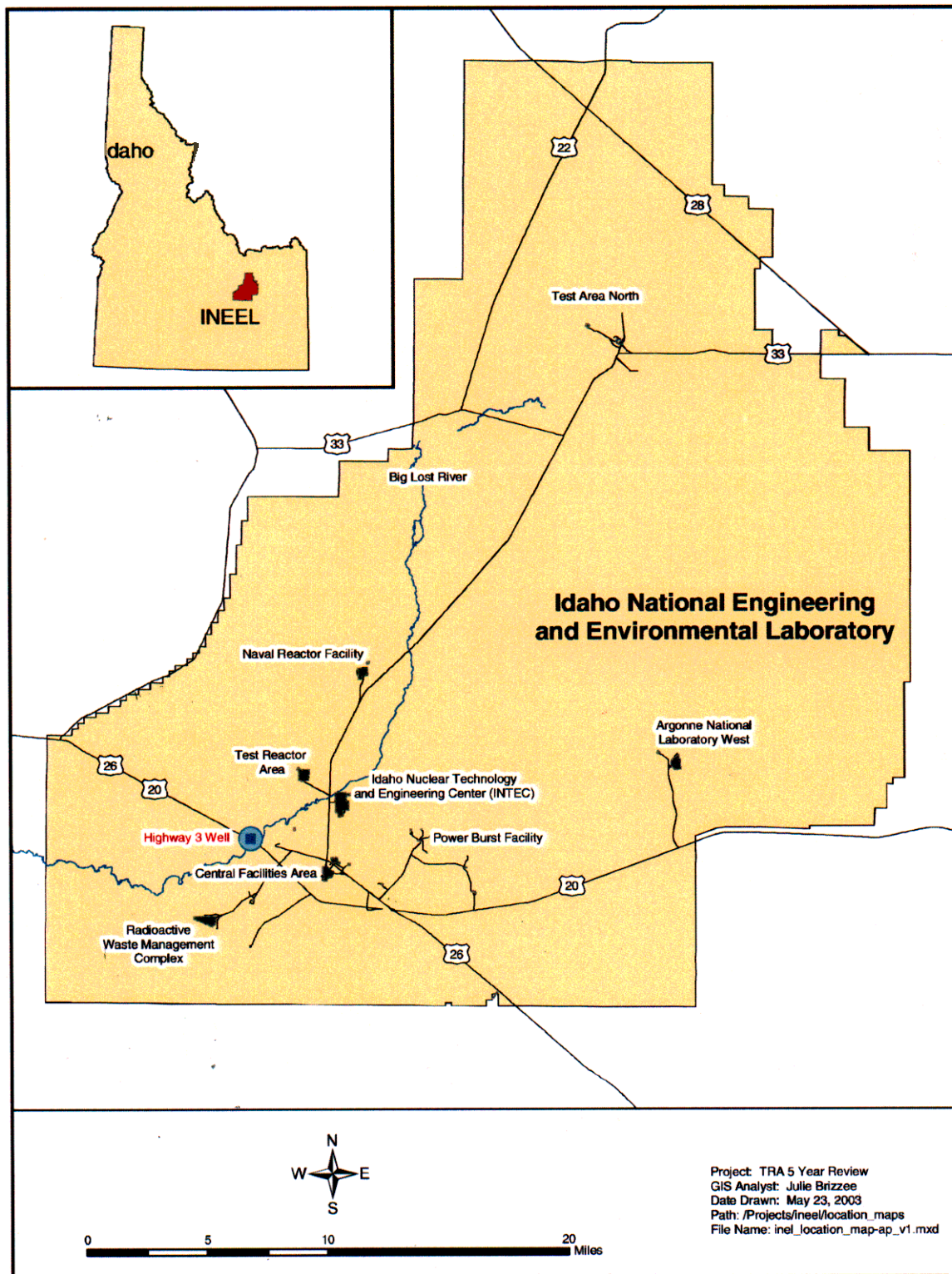


Figure 2. Map showing the location of the Idaho National Engineering and Environmental Laboratory and its facilities.

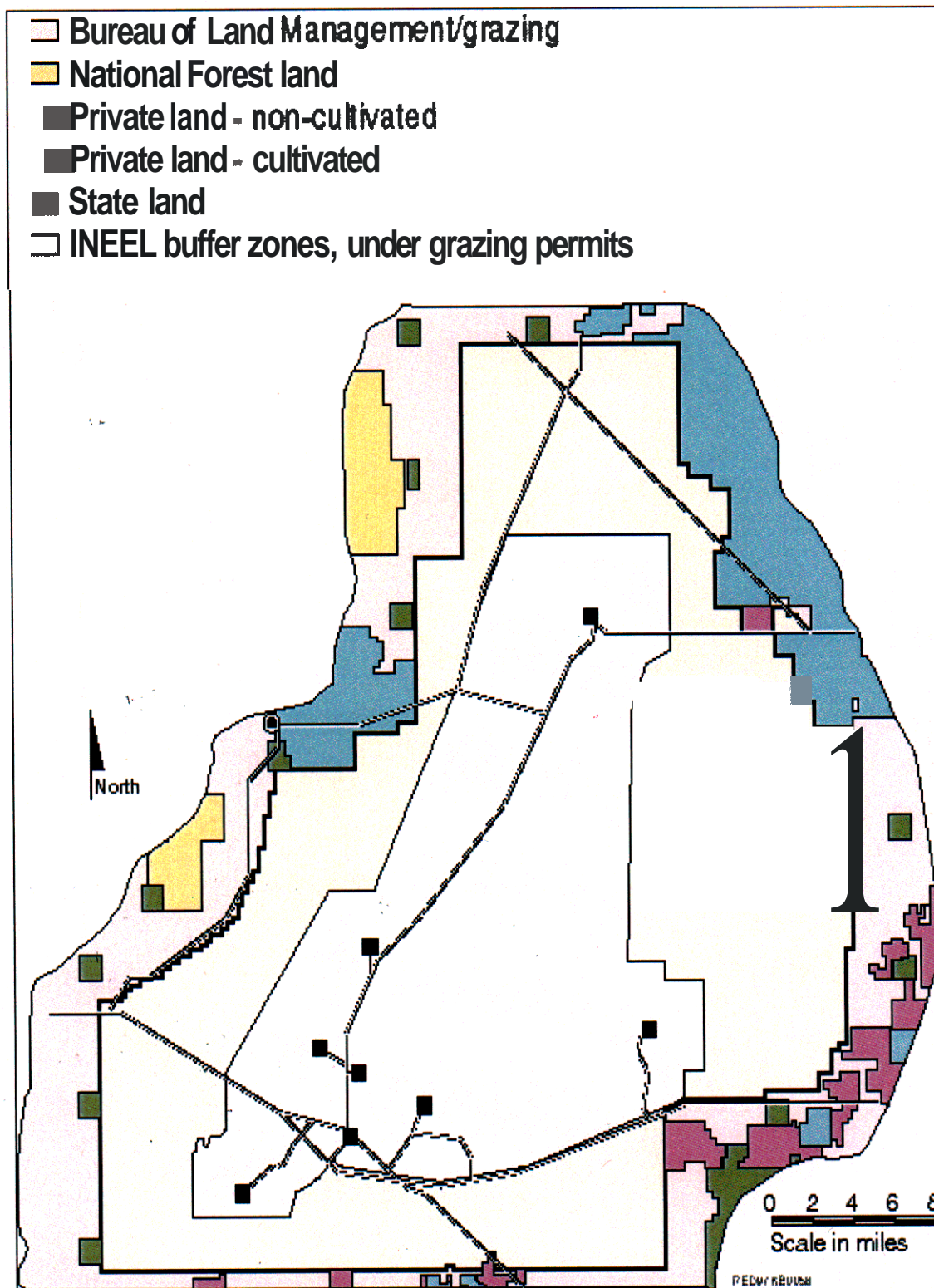


Figure 3. Land ownership and use on and surrounding the Idaho National Engineering and Environmental Laboratory.

5. REMEDIAL ACTIONS

The OU 2-13 Record of Decision (DOE-ID 1997b) was signed on December 22, 1997. Remedial action objectives were developed based upon data collected during the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a). Of the 55 identified sites at TRA, eight were identified for remediation in the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a). The OU 2-13 Record of Decision (DOE-ID 1997b) determined that four sites would require active action and four sites would require limited action. The Explanation of Significant Differences (DOE-ID 2000a), signed in May 2000, documented the required institutional controls for these eight sites and added seven additional sites for institutional controls from the original 47 no action sites.

5.1 Remedial Action Objectives

Remedial action objectives for the eight sites of concern were developed in accordance with 40 CFR 300, “National Oil and Hazardous Substances Pollution Contingency Plan,” and CERCLA remedial investigation/feasibility study guidance through meetings with IDEQ, EPA, and DOE. The remedial action objectives result from risk assessments and are specific to the contaminants of concern and exposure pathways developed for OU 2-13.

The remedial action objectives for protection of human health and safety are described below:

- Inhibit direct exposure to radionuclide contaminants of concern in soil that would result in a total excess cancer risk of greater than 1 in 10,000 to 1,000,000 (1E-04 to 1E-06) to current and future workers and future residents
- Inhibit ingestion of chemical and radionuclides containing contaminants of concern in soil by all affected exposure routes (including ingestion of soil, groundwater, and homegrown produce) that would result in a total excess cancer risk of greater than 1 in 10,000 to 1,000,000 (1E-04 to 1E-06) or a hazard index greater than 1 to current and future workers and future residents
- Inhibit the degradation of any low-level-waste repository covers (e.g., Warm Waste Pond 1952 and 1957 cell covers) that would result in exposure to either the buried waste or the migration of contaminants to the surface that would pose a total excess cancer risk (for all contaminants) of greater than 1 in 10,000 to 1,000,000 (1E-04 to 1E-06) or a hazard index greater than 1 to current and future workers and future residents.

The remedial action objectives for protection of the environment are described below:

- Inhibit adverse effects to resident populations of flora and fauna, as determined by the ecological risk evaluation from soil, surface water, or air containing contaminants of concern
- Inhibit adverse effects at sites where contaminants of concern remain in place, which could result in exposure to contaminants of concern or migration of contaminants of concern to the surface.

To meet these remedial action objectives, preliminary remediation goals were established as quantitative cleanup levels based primarily on applicable or relevant and appropriate requirements and risk-based doses. Final remediation goals are based on the results of the baseline risk assessment and an evaluation of expected exposures and risks for selected alternatives. Table 2 presents the final remediation goals. Remedial actions were completed to ensure that risk would be mitigated and exposure would not exceed the final remediation goals.

Table 2. Final remediation goals for Operable Unit 2-13 sites.

Site	Contaminated Media	Contaminant of Concern	Final Remediation Goals (mg/kg for Nonradionuclides) (pCi/g for Radionuclides)""
Warm Waste Pond (TRA-03)	Soil	Ag-108m* Cs-137" Eu-152*	0.39 7.78 99.9
Chemical Waste Pond (TRA-06)	Soil	Ba Mn Hg Zn	926 146 0.47 43.3
Cold Waste Pond (TRA-08)	Soil	As Cs-137"	18.3 23.3
Sewage Leach Pond (TRA-13)	Soil	Hg Zn Ag-108m* Cs 137*	0.94 86.6 0.58 11.7
Soil surrounding hot waste tanks at Building 613 (TRA-15)	Soil	Cs-137"	23.3
Soil surrounding Tanks 1 and 2 at Building 630 (TRA-19)	Soil	Cs-137"	23.3
Brass Cap Area	Soil	Cs-137"	23.3
Sewage Leach Pond berm and soil contamination area	Soil	Cs-137"	23.3

a. Final remediation goals are soil concentrations of contaminants of concern that would result in a cumulative excess cancer risk of 1 in 10,000 or a hazard index greater than 1 for the 100-year residential exposure scenario. These might vary during the actual cleanup, in recognition of natural background levels as established in *Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory* (Rood, Harris, and White 1996), and in recognition that cleanup to within the acceptable risk range could be achieved with a different mix of the contaminants of concern than was assumed in establishing these final remediation goal values.

b. These final remediation goals are not relevant to the sites where the selected remedy is containment. The remedial action objectives will be met by installing a cover to the exposure pathway.

* = Contains radionuclides

TRA = Test Reactor Area

5.2 Remedy Implementation

The following subsections describe the remedial actions implemented at the OU 2-13 sites. A full description of the remedial actions is located in the *Remedial Action Report for the Test Reactor Area Operable Unit 2-13* (DOE-ID 2000b).

5.2.1 TRA-03: Warm Waste Pond (Sediments)

Remedial activities were conducted at the TRA Warm Waste Pond in 1999. Engineered soil covers were placed over the covers constructed during interim actions. Cell 1964 was covered with native soil.

Cell 1952 was covered with pea gravel, cobble, and then a second layer of pea gravel. After placement of radiologically contaminated soil from the north Cold Waste Pond, Cell 1957 was covered with soil, pea gravel, cobble, and another layer of pea gravel. Then all three cells were covered by a riprap layer, approximately 2 ft thick, to inhibit human intrusion.

Preremediation occupational and residential risks are contained at this site beneath the engineered cover. Institutional controls were established, thereby restricting the site to occupational access for more than 30 years and restricting the site to industrial land use only for more than 100 years but less than 1,000 years until residential risk is $<10^{-04}$, based on the results of a 5-year review.

5.2.2 TRA-06: Chemical Waste Pond

Remedial activities were conducted at the Chemical Waste Pond in 1999. A native soil cover was constructed over the former waste pond. The soil cover was a three-layer design, consisting of a layer of gravel and coarse sand; a compacted, low permeability layer; and a topsoil layer. The topsoil layer was reseeded with native vegetation to control erosion.

Institutional controls were established restricting residential land use to depths <14 ft where an Hg hazard remains. Industrial land use is unrestricted. Recently available EPA information could be used to re-evaluate and increase the original OU 2-13 Record of Decision's conservative final remediation goal for mercury. (See the *End of Well Report for MIDDLE-1823 Waste Area Group 10 Deep Corehole Vertical Profile* [INEEL 2003] for an example of where a reevaluation was done.)

5.2.3 TRA-08: Cold Waste Pond

The Cold Waste Pond remains in use today; Contamination found in the Cold Waste Pond is believed to be due to windblown contamination. The presence of Cs-137 is attributed to windblown soil contamination originating from the Warm Waste Pond, and the presence of arsenic is the result of historic disposal practices at the pond. Post-Record of Decision sampling data (DOE-ID 1998a) confirmed that the pond sediments are below the 18.3-mg/kg final remediation goal for arsenic and the Resource Conservation and Recovery Act (RCRA) toxicity characteristic leaching procedure's regulatory limit. Therefore, arsenic was eliminated as a contaminant of concern, and the final remediation goal for Cs-137 was increased from 11.7 to 23.3 pCi/g (DOE-ID 2000b).

Remedial actions were conducted at the Cold Waste Pond in 1999. Approximately 80 yd³ of Cs-137-contaminated soil from the northern ponds was removed and transported to the Warm Waste Pond Cell 1957 for disposal. Institutional controls were established, thereby restricting the site to industrial land use for less than 100 years until residential risk is $<10^{-04}$, based on the results of a 5-year review.

5.2.4 TRA-13: Sewage Leach Pond and Sewage Leach Pond Berm

Remedial actions were conducted at the Sewage Leach Pond in 1999. Approximately 1,431 yd³ of soil contaminated with Cs-137 concentrations greater than 23.3 pCi/g was excavated from the Sewage Leach Pond berms and placed in the bottom of the Sewage Leach Pond. A three-layer native soil cover was then constructed over the Sewage Leach Pond with a minimum thickness of 10 ft, consisting of a layer of gravel and coarse sand; a compacted, low-permeability layer; and a topsoil layer. Clean soil (6 in.) was placed over the soil contamination area that surrounds the Sewage Leach Pond. The topsoil layer and the soil contamination area were reseeded with native vegetation to control erosion.

Institutional controls were established restricting the site to occupational access for more than 30 years as well as restricting the site to industrial land use only until residential risk is $<10^{-04}$.

5.3 Limited Action Sites

Limited action sites in OU 2-13 include TRA-15, TRA-19, the Brass Cap Area, and the Sewage Leach Pond's soil contamination area. Actions taken at these sites were limited to institutional controls, with the contingent excavation and disposal option for TRA-19 and the Brass Cap Area to be used if necessary. The institutional controls for each of the sites are summarized in the following subsections.

5.3.1 TRA-15

Restrict occupational access for 25 more years and residential access for approximately 95 more years until risk is $<10^{-04}$, based on the results of a 5-year review. After the aforementioned restriction is removed, restrict land use at depths >10 ft until otherwise evaluated.

5.3.2 TRA-19

Restrict occupational access and prohibit residential development for at least 95 more years until soil is removed or status is changed, based on the results of a 5-year review.

5.3.3 Brass Cap Area

Restrict occupational access and prohibit residential development for at least 95 more years until soil is removed or status is changed, based on the results of a 5-year review.

5.3.4 Sewage Leach Pond—Soil Contamination Area

Restrict occupational access for approximately 25 more years and residential access for less than 95 more years until risk is $<10^{-04}$, based on the results of a 5-year review.

5.4 Institutional Control Sites

Subsequent to the completion of the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a) and signing of the OU 2-13 Record of Decision (DOE-ID 1997b), a reevaluation of the data was performed and seven of the no action sites were determined to require institutional controls to ensure adequate protection of human health and safety and the environment. The Explanation of Significant Differences (DOE-ID 2000a), prepared and approved in May 2000, identified and documented the required institutional controls—all of which have been implemented. The institutional controls identify these areas as CERCLA sites, restrict access, and ensure that the remedies remain protective of human health and safety and the environment until contaminant concentrations decrease to levels that allow for unlimited use and unrestricted access. Institutional controls have been implemented to ensure that land use assumptions used in the risk assessments are preserved. The institutional controls implemented at each site are summarized as follows:

- **PCB Spill at TRA-619:** Permanently restrict this site to industrial land use only, unless otherwise indicated, based on the results of a 5-year review.
- **PCB Spill at TRA-626:** Permanently restrict this site to industrial land use only, unless otherwise indicated, based on the results of a 5-year review.
- **PCB Spill at TRA-653:** Permanently restrict this site to industrial land use only, unless otherwise indicated, based on the results of a 5-year review.

- **Warm Waste Retention Basin:** Restrict this site to industrial land use only for <10 ft for approximately 25 more years. Restrict land use for deeper soil (approximately 40 ft), unless otherwise indicated, based on the results of a 5-year review.
- **TRA-34 (North Storage Area):** Restrict site to industrial land use only until residential risk is $<10^{-04}$, in approximately 25 more years based on the results of a 5-year review.
- **Hot Tree Site:** Restrict site to industrial land use only for approximately 25 years more until residential risk is $<10^{-04}$, based on the results of a 5-year review.
- **Perched Water and Snake River Plain Aquifer (No Action with Monitoring):** Restrict drilling of wells for the purpose of drinking water use until contaminant concentrations are below the maximum contaminant levels, based on the results of a 5-year review.

5.5 No Action Sites

The remaining 47 sites evaluated under the Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 1997a) were designated as no action sites in the OU 2-13 Record of Decision (DOE-ID 1997b). These sites were determined to pose no unacceptable risks to human health and safety and the environment. A list of these sites is contained in the OU 2-13 Record of Decision (DOE-ID 1997b). A review of planned land use indicates that the land use assumptions made in the OU 2-13 Record of Decision are still valid.

6. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This is the first five-year review for the site.

7. FIVE-YEAR REVIEW PROCESS

7.1 Administrative Components

The DOE-ID is the lead agency for the 5-year remedy review at the OU 2-13 sites. The EPA retains final authority in determining the completeness of the 5-year review. Members of the 5-year review consisted of representatives from DOE, EPA, and IDEQ, as well as personnel from the INEEL's operations and maintenance contractor — BechtelBWXT Idaho, LLC. The EPA, IDEQ, DOE, and Bechtel BWXT Idaho, LLC, personnel determined the schedule and content of the 5-year review during a conference call held on March 7, 2002.

7.2 Community Involvement

This section describes the required public notification for the 5-year remedy review of OU 2-13. The INEEL stakeholders and the public were notified of the 5-year review schedule, and input was requested. No responses from the community were received. A copy of the press release is included in Appendix A. Notifications were made on August 5, 2002, in the following newspapers:

- Arco Advertiser — Arco, Idaho
- Idaho State Journal — Pocatello, Idaho
- The Idaho Statesman — Boise, Idaho
- Idaho *Unido* — Pocatello, Idaho

- *Moscow-Pullman Daily News* — Moscow, Idaho/Pullman, Washington
- *The Post Register* — Idaho Falls, Idaho
- *Sho-Ban News* — Fort Hall Reservation
- *The Times News* — Twin Falls, Idaho.

7.3 Site Inspections

Site inspections were conducted annually for each site as required by the OU 2-13 Record of Decision (DOE-ID 1997b), implemented in the *Operations and Maintenance Plan for the Final Selected Remedies and Institutional Controls at Test Reactor Area, Operable Unit 2-13* (DOE-ID 2000c), and documented in annual reports. The most recent annual report is used by reference to satisfy EPA requirements in completion of this 5-year review. The most recent site inspection was completed on June 26, 2002. The site inspections included a visual inspection of the engineered soil covers, vegetation, and riprap covers; radiological surveys also were performed on the Warm Waste Pond and Sewage Leach Pond to determine the extent, if any, of contaminant migration. Visual site inspections showed that the engineered covers and vegetation are functioning as designed. The covers showed no signs of erosion or animal intrusion. Vegetation was noted as sparse.

The most recent annual radiological survey indicated that the remedy was functioning as intended. A review of the radiological surveys from 2000–2002 indicated no issues of concern. A full discussion of the radiological surveys is located in the *FY-2002 Annual Institutional Controls Inspection Report for the Test Reactor Area, Operable Units 2-13 and 2-14 (Final)* (INEEL 2002).

A review of the institutional controls indicated that the institutional controls are functioning as intended. Based on previous risk evaluations, these institutional controls will need to be maintained for at least 25 more years, at which time they should be reevaluated. Site inspection forms and the radiological survey maps are located in Appendix D.

7.4 Document Review

Documents pertaining to the Records of Decision, site inspections, and monitoring results were reviewed during preparation of this document and are summarized here. A complete list of associated documents is located in Appendix B.

7.5 Review of Enforceable Milestones

The *Record of Decision, Test Reactor Area Perched Water System, Operable Unit 2-12, Idaho National Engineering Laboratory, Idaho Falls, Idaho* (DOE-ID 1992) was signed in 1992 and documented the perched water system's history. The OU 2-12 Record of Decision defined three water bodies beneath the TRA: (1) a shallow perched water zone, (2) a deep-perched water zone, and (3) the SRPA. The shallow perched water system was defined as saturated conditions occurring in the vadose zone in the "immediate vicinity of the ponds and retention basin... (that) forms on the interface between the surficial alluvium and the underlying basalts at about 50 feet below land surface." The deep-perched water system was defined as beginning "at depths of approximately 140 feet below land surface and ends at depths of about 200 feet below land surface." The SRPA is located approximately 450 ft bgs and has a flow rate of about 4.3 ft/day near TRA (DOE-ID 1992).

The selected remedy under the OU 2-12 Record of Decision (DOE-ID 1992) was "no action with monitoring." The Explanation of Significant Differences (DOE-ID 2000a) established institutional

controls for the aquifer and perched water. The OU 2-13 Record of Decision (DOE-ID 1997b), signed in 1997, later included and summarized the selected remedies of the OU 2-12 Record of Decision (DOE-ID 1992). The OU 2-13 Record of Decision designated the perched water and aquifer as an area of concern, and a groundwater monitoring plan was required for both perched water and aquifer monitoring. Aquifer monitoring was required due to the potential for contaminants of concern in the perched water system to migrate downward to the aquifer and as a result of contaminants disposed directly to the aquifer via the TRA disposal well. Aquifer monitoring provides information on contaminant trends and verifies the adequacy of the selected remedy.

8. GROUNDWATER MONITORING

Because groundwater is an important pathway for risk to human health and the environment, and is the focus of protection in the OU 2-13 Record of Decision (DOE-ID 1997b), an in-depth discussion of the hydrogeology and water quality is provided in this 5-year review. The following sections provide (1) a brief history of groundwater monitoring at TRA; (2) a discussion of the contaminants of concern that are in the groundwater pathway; (3) the hydrogeologic framework, including perched water formation and aquifer flow characteristics; and (4) an analysis of TRA groundwater sampling data.

For over 50 years, groundwater investigations have been ongoing near the TRA for characterizing the SRPA's overall quality and for determining the impact of facility operations on the aquifer. In the 1950s, the United States Geological Survey (USGS) began a program of installing monitoring wells and evaluating contaminant migration from the perched water to the aquifer. Beginning in the mid-1980s, INEEL contractors performed monitoring to satisfy various regulatory requirements. Groundwater monitoring under CERCLA has been ongoing at the TRA under the requirements of the OU 2-12 and OU 2-13 Records of Decision (DOE-ID 1992, 1997b). The USGS continues to monitor selected wells at the TRA, and these data are used to supplement information collected under CERCLA-driven monitoring. Data compiled and examined during completion of this 5-year review include water samples and water elevation measurements collected between March 1961 and March 2003.

One of the conditions stated in the OU 2-12 Record of Decision (DOE-ID 1992) was that a groundwater monitoring plan would be prepared within 45 days following signature of the document. The *Post-Record of Decision Monitoring Plan for the Test Reactor Area Perched Water System Operable Unit 2-12* (Dames & Moore 1993) included the analysis and evaluation of groundwater samples for contaminants of concern. The data collected under the Post-Record of Decision Monitoring Plan were used to verify trends in the SRPA predicted by pre-Record of Decision computer modeling, to evaluate the effects of discontinued discharge to the Warm Waste Pond, and to ensure protectiveness of human health and the environment.

Groundwater modeling completed before the signing of the OU 2-12 Record of Decision (DOE-ID 1992) predicted the dissipation of perched water within 6 years following cessation of discharge to all disposal ponds. The modeling also predicted that tritium levels within the aquifer would drop below the maximum contaminant level (MCL) (20,000 pCi/L) by 2004, chromium levels would meet or drop below the MCL (0.1 mg/L) by 2016, and that cadmium would drop below its MCL (0.005mg/L) by 2029 (Dames & Moore 1992). It is important to note the following:

1. Perched water has remained and will remain beneath TRA as long as the discharge of significant quantities of water continues to the Cold Waste Pond
2. Predicted trends made by the pre-Record of Decision model are for aquifer concentrations only (not perched water)

3. The pre-Record of Decision model assumed cessation of discharge to the Cold Waste Pond in 2007 with closure of the TRA facility.

The Post-Record of Decision Monitoring Plan (Dames & Moore 1993) specified that groundwater sampling and analysis for all contaminants of concern would be performed quarterly (four times a year) for six deep-perched water wells (Wells PW-11, PW-12, USGS-053, USGS-054, USGS-055, and USGS-056) and would be performed semiannually (twice a year) for four aquifer wells (Wells Highway 3, TRA-07, USGS-058, and USGS-065). Wells TRA-08 and TRA-06A were added to the list of aquifer wells in 1996 and 1997, respectively. The USGS has been collecting groundwater samples from wells near TRA since the 1960s. The USGS sampling has varied over the years in terms of wells, analytes, and frequency of sampling. Data from wells surrounding the TRA sampled by the USGS, but not required under the Groundwater Monitoring Plan were included in this 5-year review. Figures 4 and 5 show the locations of these and other perched water and aquifer wells, respectively, that are routinely sampled near TRA. A list of wells with data reviewed for this 5-year review is located in Appendix H.

During the 3 years following the signature of the OU 2-12 Record of Decision (DOE-ID 1992), annual technical memoranda were prepared that documented trends in groundwater contaminants and correlated the measured values to those of the pre-Record of Decision modeling (Jessmore 1994; Amett, Meachum, and Jessmore 1995; Amett, Meachum, and Jessmore 1996). These assessments reported that the selected remedy was functioning as intended. Based on the groundwater sampling through 1995, recommendations were made to reduce the number of analyzed constituents in the *Post Record of Decision Monitoring for the Test Reactor Area Perched Water System OU 2-12 — Second Annual Technical Memorandum* (Amett, Meachum, and Jessmore 1995).

8.1 Contaminants of Concern

Under the *Groundwater Monitoring Plan for the Test Reactor Area Operable Unit 2-13* (DOE-ID 2003), both perched and aquifer wells were sampled for the radiological contaminants americium (Am-241), cesium (Cs-137), cobalt (Co-60), strontium (Sr-90), tritium (H-3), and the inorganic contaminants arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), fluoride (F), lead (Pb), manganese (Mn), and mercury (Hg). Table 3 presents analyte-specific action levels and background concentrations for the identified contaminants.

Water quality results show little impact (most levels near detection limits) for Am-241, As, Be, Cd, Cs-137, F, Pb, Mn, and Hg. A full discussion of these contaminants of concern is presented in Appendix C. The contaminants of concern with higher concentrations (Cr, H-3, and Sr-90) are discussed in detail in the following subsections. The deep-perched water section also includes a discussion of Co-60. The analytical data are located in Appendix C.

8.2 Hydrogeologic Framework

The TRA is located on an alluvial plain that consists of surficial sediment with thickness ranging from 30 to 75 ft. A series of basalt flows interbedded with sedimentary deposits of eolian and fluvial origin underlies the surficial sediments. The sedimentary interbeds vary in both thickness and lateral extent. Loose, rubble-like basalt contacts—often highly vesiculated—are usually very permeable water-bearing intervals in both the perched water zones and aquifer. The basalt/sediment interfaces have much lower permeabilities and act as aquitards and perching layers. A simplified hydrogeologic cross-section showing basalt and interbed stratigraphy beneath TRA is provided in Figure 6. For the purposes of this report, geologic units are lumped into either basalt or sediment and no attempt is made to further define basalt subunits or specific sedimentary interbeds, as done in recent USGS publications (Anderson 1991).

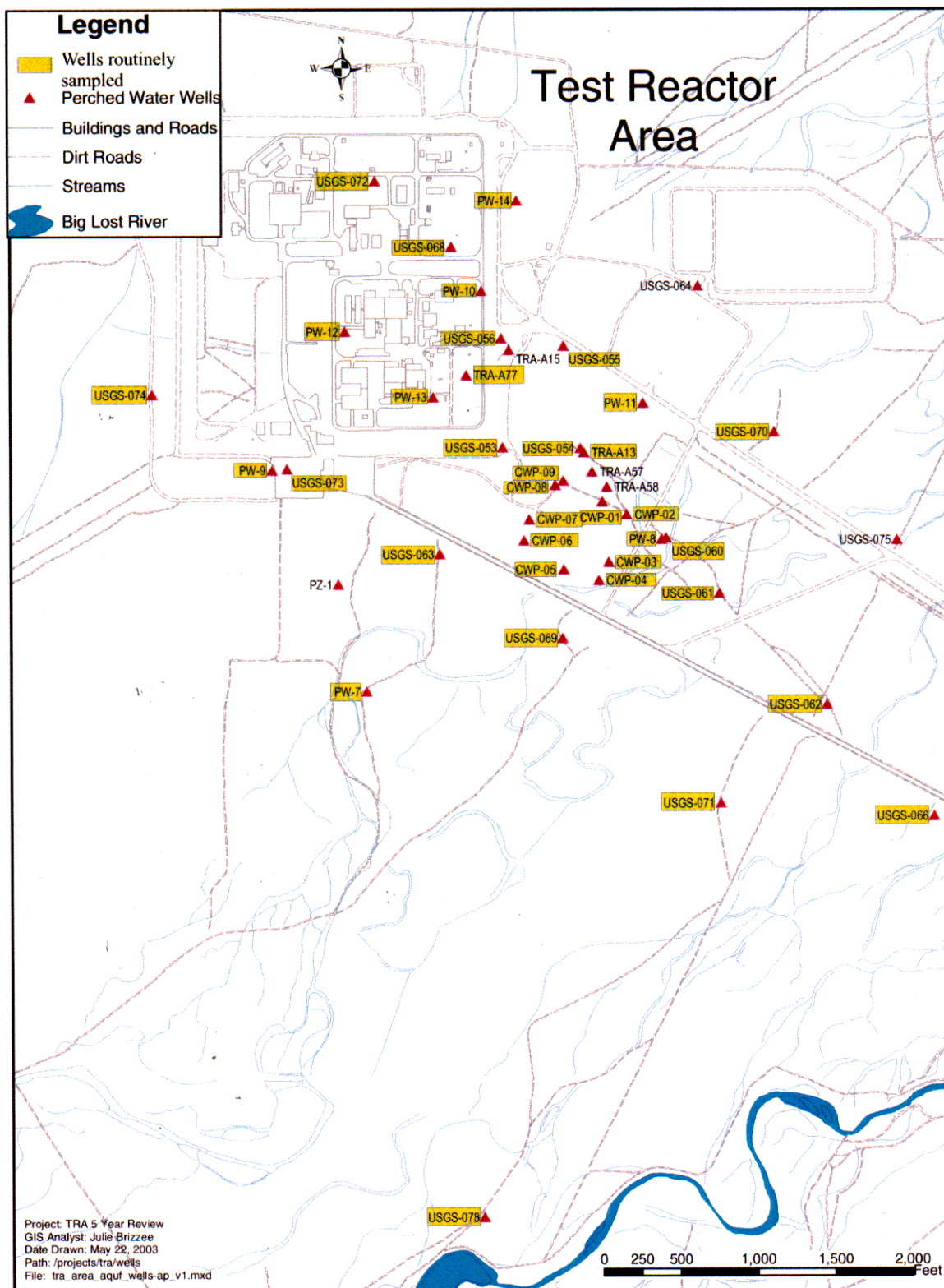


Figure 4. Map of perched-water monitoring wells at Test Reactor Area.

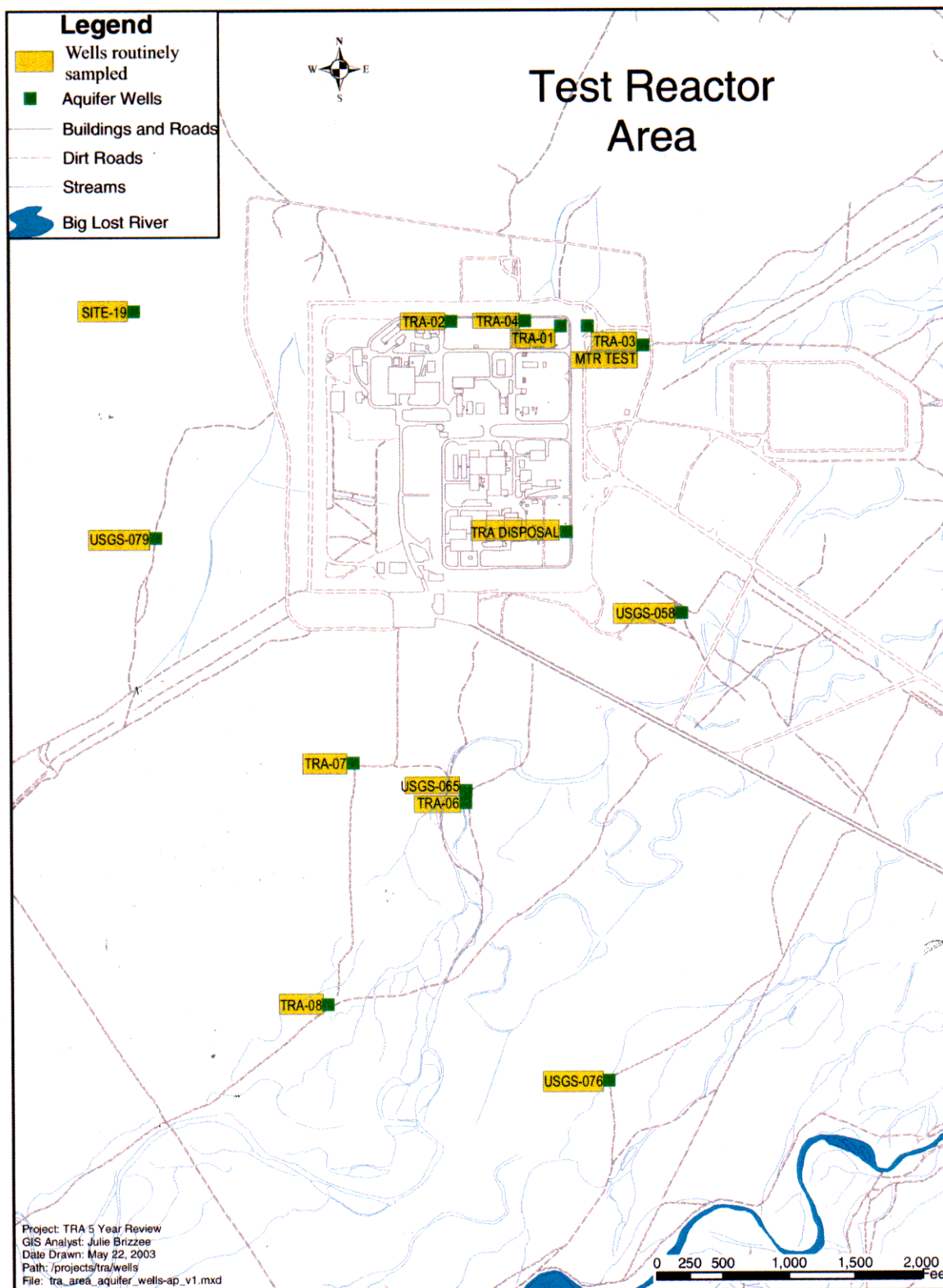


Figure 5. Map of aquifer monitoring wells at Test Reactor Area.

Table 3. Maximum contaminant levels and background concentrations for analytes.

Type	Contaminant	Maximum Contaminant Level	PQL-IDL Required ^e	Analytical Method	SRPA Background Levels ^d
Inorganics:	Arsenic (As) ⁱ	0.05 mg/L	0.01 mg/L	EPA-600/4-79-020 ^b	0.003 mg/L
	Beryllium (Be)	0.004 mg/L	0.0008 mg/L	EPA-600/4-79-020 ^b	0.003 mg/L
	Cadmium (Cd)	0.005 mg/L	0.001 mg/L	EPA-600/4-79-020 ^b	<0.001 mg/L
	Chromium (Cr)	0.1 mg/L—Total	0.01 mg/L	EPA-600/4-79-020 ^b	0.003 mg/L
	Fluoride (F) ["]	4 mg/L	0.5 mg/L	EPA-600/4-79-020 ^c	0.5 mg/L
	Lead (Pb)	0.015 mg/L ^f	0.003 mg/L	EPA-600/4-79-020 ^b	0.005 mg/L
	Manganese (Mn) ["]	0.05 mg/L ^g	0.020 mg/L	EPA-600/4-79-020 ^b	0.003 mg/L
	Mercury (Hg)	0.002 mg/L	0.0002 mg/L	EPA-600/4-79-020 ^b	0.0001 mg/L
Radionuclides:	Gross Alpha (α) (including Am-241)	15 pCi/L—Total	4 pCi/L	Gas flow proportional counting	Not naturally occurring
	Gross Beta (β)	<4 mrem/yr	25 pCi/L	Gas flow proportional counting	8.4+/- 1.1 pCi/L ^h
	Gamma emitters (γ) (including Cs-137 and Co-60)	200 pCi/L—Total	100 pCi/L	Gamma spectrometry	Not naturally occurring
	Tritium (H-3)	20,000 pCi/L	400 pCi/L	Liquid scintillation counting	42+/-9 pCi/L ^h
	Strontium-90 (Sr-90)	8 pCi/L	1 pCi/L	Gas flow proportional counting	0.07+/-0.05 pCi/L ^h

a. Sampled every 5 years as required by the *Final Record of Decision, Test Reactor Area, Operable Unit 2-13* (DOE-ID 1997b).

b. By EPA Document No. EPA-600/4-79-020 or EPA-600/R-04/111 methods in conjunction with INEEL ER-SOW-156 specifications for Sample Delivery Group Type 1C data.

c. By Standard Method Part 4500 F (Method C, D, or E) of EPA Method 300.0 (Revision 2.1), 340.1, 340.2, or 340.3 in conjunction with INEEL ER-SOW-156 specifications for Sample Delivery Group Type 3 data.

d. U.S. Geological Survey Water-Resources Investigation Report 91-4015.

e. PQL = practical quantitation limit; IDL = instrument detection limit; should be at least half the MCL value.

f. Action level

g. Secondary standard

h. Background values for offsite wells are from *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical Constituents in Ground Water in the Vicinity of the Idaho National Engineering Laboratory* (Orr, Cecil, and Knobel 1991).

i. New MCL for arsenic will be 0.01 mg/L in 2006.

DOE-ID = U.S. Department of Energy Idaho Operations Office

EPA = U.S. Environmental Protection Agency

INEEL = Idaho National Engineering and Environmental Laboratory

MCL = maximum contaminant level

SRPA = Snake River Plain Aquifer

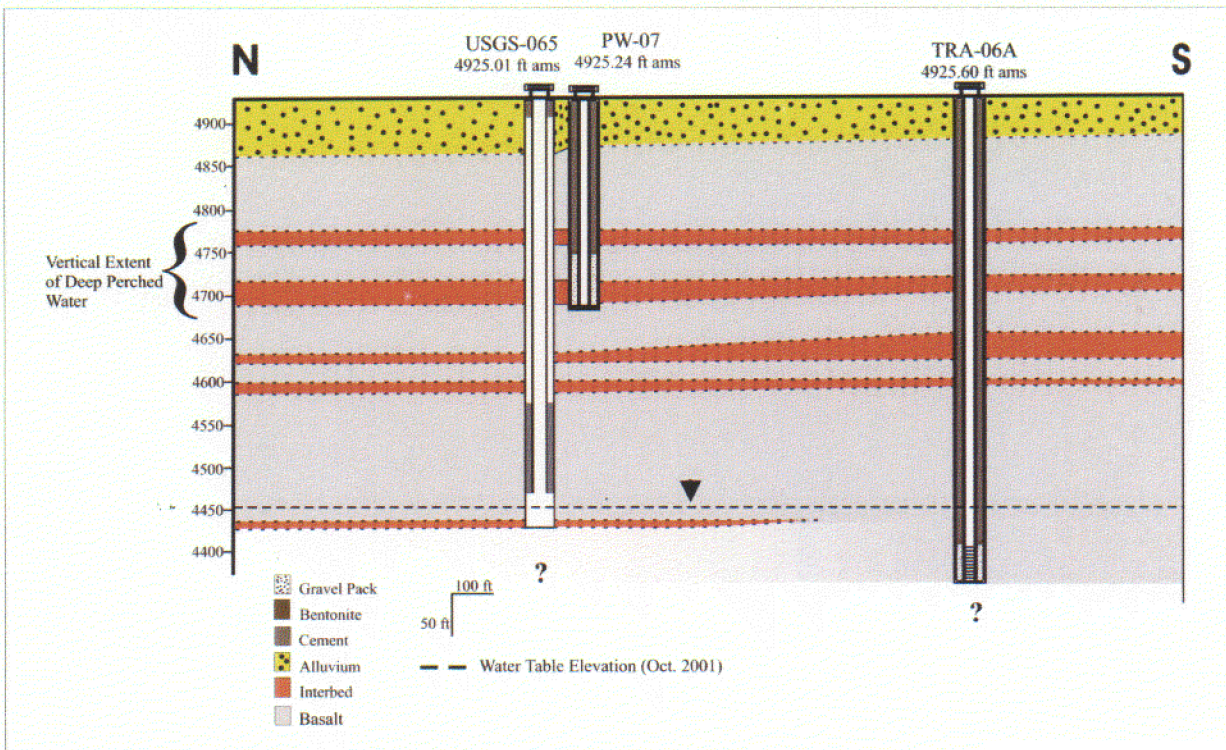


Figure 6. Stratigraphic cross-section near Wells USGS-065 and TRA-06A.

8.2.1 Perched Water Formation

Perched water forms in the vadose zone when the rate of infiltrating water exceeds the capacity of a low-permeability layer to transmit water. Barriers to the vertical migration of water cause saturated conditions to occur. Water spreads laterally following the slope of the contact. The size or “footprint” of the perched water body expands until sufficient area is wetted to transmit the flux of infiltrating water. Thus, widespread layers with very low permeability will form larger perched water bodies. The footprint and depth of the perched water body will increase or decrease as the rate of infiltration increases or decreases. A conceptual drawing showing the development of perched water beneath TRA is shown in Figure 7.

Two perched water zones have been recognized below TRA due to discharge of water to the TRA ponds. Historically, the Cold Waste Pond has been the largest source of water to the perched water zones; it currently (from 1998–2003) receives an average of about 380 gpm of water. In the past, other surface sources of water, including the former Warm Waste Pond and the Chemical Waste Pond, represented only a small percentage of the total input to the subsurface. A history of liquid effluent discharge to ponds for the period of 1982–2003 is shown in Figure 8.

There is a strong correlation between water-level patterns in the perched water system and the discharge rates to the Cold Waste Pond. The thickness and size of the two perched water zones have changed over time, depending on the amount of water discharged to the ponds. The relationship between pond discharge and the footprint of the perched water bodies has been tracked and described in numerous reports (Hull 1989; Doornbos et al. 1991; Dames & Moore 1992).

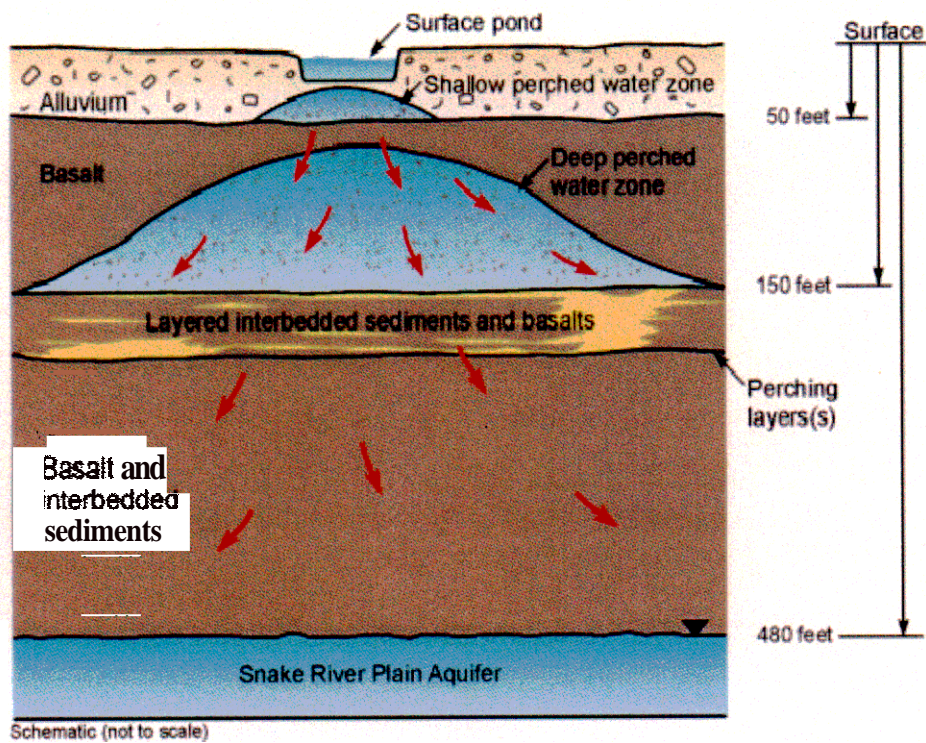


Figure I. Conceptual drawing showing the development of perched water beneath the Test Reactor Area.

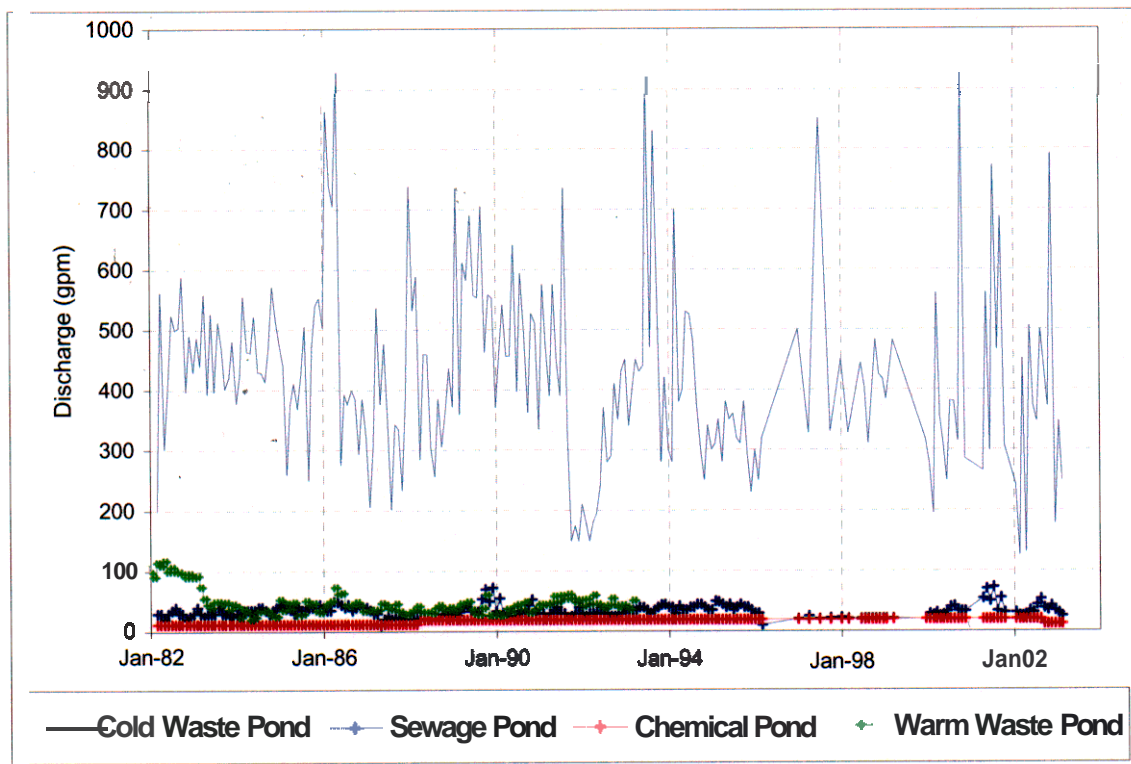


Figure 8. Historical discharges of water to Test Reactor Area ponds.

The shallow perched water zone is formed on a layer of fine-grained sediments at the alluvial-basalt contact—about 50 ft bgs (see Figure 6). It is monitored routinely by 11 shallow wells (CWP-01 through CWP-09, TRA-A13, and TRA-A77) (see Figure 4). Because of variations in discharge, most of the shallow perched-water wells have shown episodic wetting and drying since 1990 (CWP-01 and CWP-09 have been continually wet over the period of record). When the Warm Waste Pond was removed from service in 1993 and replaced by a lined evaporation pond, the volume of infiltrating water was decreased slightly as noted in Figure 8. However, the result of this decrease was small and made only a slight difference in the shallow perched water zone's footprint.

The deep-perched zone has developed between 140 and 200 ft bgs on a combination of low-permeability sediments, dense basalts, and basalt with sediment-filled fractures. The bracket on the left of Figure 6 represents the vertical extent of the composite perching layer for the deep-perched water zone. Because the deep-perched zone has a larger footprint than the shallow perched zone, it is thought that this layer's composite permeability is lower than the perching layer for the shallow perched water zone or, alternatively, the deep perching horizon is of larger areal extent and water flows off the edge of a smaller perching layer beneath the shallow perched water zone. The deep-perched water zone is monitored by 28 wells that are sampled routinely for contaminants of concern.

Figure 9 is a contour map of the deep-perched zone from the OU 2-12 Record of Decision (DOE-ID 1992). The deep-perched water zone can be seen to range in elevation from less than 4,750 ft to greater than 4,860 ft, it is elongated in a northwest to southeast direction, and it generally has a broad, flat top with steeply sloping flanks. Figure 10 is the same area with contours on the surface of the deep-perched zone for April 2003. Twelve years later, the deep-perched zone is narrower and the elevations range from less than 4,730 ft to greater than 4,850 ft. The deep-perched zone is still flat topped with steeply dipping sides, but the highest elevation is now centered beneath the Cold Waste Pond. The hydrographs of most wells tapping the deep-perched zone have shown a marked decrease in water elevation over the same period of March 1991 to April 2003. The hydrographs contained in Appendixes F and G show decreases in water levels ranging from 3 to 45 ft, with an average of 13 ft. This is most likely attributed to the decreased discharge to the ponds between 1991 and 2003. Although it is not apparent from Figure 8, the average discharge rate to the Cold Waste Pond between early 1982 and late 1991 was 460 gpm. Since late 1991, discharges to the Cold Waste Pond have averaged 380 gpm. It is important to note when comparing Figures 9 and 10 that the apex of the deep-perched zone is now centered beneath the Cold Waste Pond where formerly it had been larger, extending to the northwest beneath the old Warm Waste Pond and the TRA facility.

8.2.2 Snake River Plain Aquifer beneath the Test Reactor Area

The SRPA occurs approximately 450 ft below TRA and consists of a series of saturated basalt flows and sedimentary materials. The aquifer is relatively permeable due to the presence of fractures, fissures, and rubble zones at contacts between individual basalt flows. On October 7, 1991, the EPA designated the SRPA as a sole-source aquifer under the "Safe Drinking Water Act" (42 USC § 300 et seq.).

Generally, groundwater flows to the southwest SRPA under the ambient, hydraulic gradient. Figure 11 depicts the aquifer water table in October 2002. The inherent heterogeneity of the fractured basalt aquifer makes it very difficult to contour the water table. Appendix F presents a detailed analysis of the groundwater flow direction using three-point calculations over time for sets of wells at TRA, which better represents the dynamic nature of the aquifer flow system. Figure 11 also shows the inferred direction of groundwater flow beneath TRA. The direction of flow is inferred because the aquifer's highly heterogeneous matrix creates anisotropy that can result in flow paths not perpendicular to the water level contours. Fluctuating water levels caused by recharge and pumping further complicate determination of the aquifer flow directions. Appendixes F and G provide flow rosettes and hydrographs demonstrating the

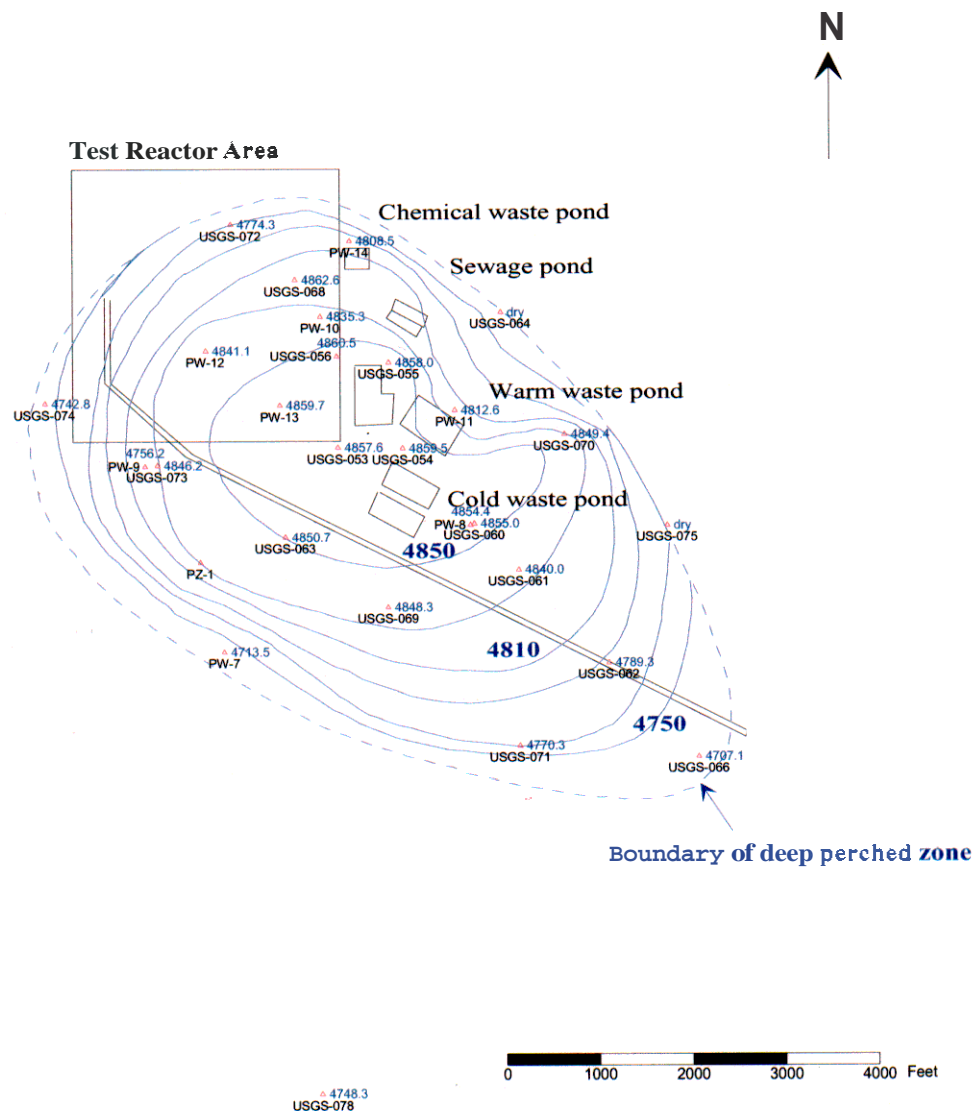


Figure 9. Configuration of the deep-perched water at Test Reactor Area, March 1991.

complexities of groundwater flow, which are greatly simplified in Figure 11. Groundwater flow beneath TRA is generally to the southwest, but the direction and water table gradient are dynamic both temporally and spatially.

Infiltrating groundwater from the deep-perched water zone moves downward over a large diffuse area, probably under varying levels of saturation, until it meets the SRPA's upper surface. The perched water recharge to the aquifer appears insufficient to cause mounding, as this has not been observed in the TRA aquifer wells. Dilution of the vadose water is thought to be significant due to the relatively fast (4.3 ft/day) rate of flow in the aquifer. However, a thin, laterally extensive sedimentary layer could restrict dilution locally beneath TRA. Wells USGS-065 and TRA-06A, although only approximately 100 ft apart, have different completion depths and, because of the sedimentary interbed, tap two different zones in the aquifer (see Figure 6). Well USGS-065 has an open-hole interval from 456–498 ft bgs. Well TRA-06A is screened from 528–558 ft bgs. As shown in Figure 6, the open interval of USGS-065 terminates in the interbed tapping about 8 ft of the aquifer above the interbed, whereas the screened interval of TRA-06A is beneath this interbed with about 40 ft of filter pack exposed to the aquifer. Dilution of contaminants arriving from the overlying vadose zone to the thin, saturated layer of aquifer water immediately above this sedimentary interbed is undoubtedly much less than in parts of the aquifer, having unrestricted vertical mixing. The presence of this sedimentary interbed, just beneath the water table, could explain the higher groundwater concentrations measured in wells completed above the interbed. Differences in concentrations that could be related to a stagnant zone near the top of the aquifer are discussed in the SRPA's analytical data review (Section 7.3.3).

It is possible that USGS-065 could be acting as a vertical conduit for flow. Thick lines represent casing in Figure 6, while thin lines represent the borehole walls. In USGS-065, well casing extends to a depth of 456 ft bgs, with a grout seal extending from 456 to 355 ft bgs. A string of casing extends from ground surface to 326.5 ft bgs, leaving an open, unsealed interval from 326.5 to 355 ft bgs. A second grout seal extends from ground surface to 15 ft. The well completion is open hole. Under saturated or "perched water" conditions, the open annulus might provide a pathway for rapid vertical migration of water to the top of the seal at 355 ft. Sloughing and caving of the formation against the well casing would help reduce this possibility, but its presence is not documented. The perched water in the area of the wells has receded and PW-07 has been dry since October 1994. Unless the deep-perched zone expands back into this area, rapid vertical transport at this location will not threaten the aquifer's water quality.

8.3 Analysis of Groundwater Sampling Data

Routine monitoring of water quality in both shallow and deep-perched water bodies and in the aquifer beneath TRA has led to a better understanding of the distribution of contaminants of concern and their relative persistence in groundwater. For the purposes of this report, data collected under CERCLA-mandated monitoring were reviewed for laboratory validation; all data passing laboratory criteria for quality are presented in Appendix C. On a well-by-well basis, data collected by the USGS are used to supplement data collected under CERCLA. Figures from the first draft of this report (included in Appendix G) use all data—regardless of data flagging—from both CERCLA sampling and the USGS. The following subsection discusses sampling results and contaminant-of-concern trends for the shallow perched water zone, deep-perched water zone, and aquifer.

8.3.1 Shallow Perched Water Analytical Review

The primary source of water to the perched water system, the Cold Waste Pond, receives only relatively uncontaminated effluent. Data for the 14 shallow perched monitoring wells are located in Appendix C. Currently, wells completed in the nearby shallow perched water zone show values for the contaminants of concern that are significantly below the MCL. Plots of Cr, tritium, and Sr-90 for the shallow perched water can be found in Appendix G—Figures 7-9, 7-10, and 7-11, respectively. Cold

Waste Pond water wells sampled for Sr-90 and H-3 average 1.0–3.0pCi/L and <200 pCi/L, respectively. One shallow well inside the TRA fence that is currently dry, TRA-A77 (see Figure 4), has undergone dramatic decreases in concentrations during the past 10 years. From October 1995 to October 1996, Sr-90 concentrations in this well plummeted from 48,200 to 4,710pCi/L. Tritium concentrations dropped from 2,650,000 pCi/L in April 1995 to 22,400 pCi/L in October 1995, and by April 1997, the H-3 concentration decreased to 1,000pCi/L. The Co-60 concentrations also decreased from 110,000 to 7,700pCi/L from October 1995 to October 1997. Well TRA-A77 went dry in June 1997, was wet again in October 1997 and January 1999, but was dry in between these periods and since January 1999. A detailed graphical display of these data can be viewed in Appendixes C and F. The higher levels of radionuclides in this well suggest that a secondary source might remain that has never been evaluated. However, as long as the area remains dry, it is unlikely that the radionuclides will be mobile.

8.3.2 Deep-Perched Water Analytical Review

The majority of the 28 wells in the deep-perched water system show fluctuating or decreasing trends in contaminant-of-concern concentrations over the sampling record. Data for the deep-perched monitoring wells can be found in Appendix C. The major contaminants of concern for the perched water zone are discussed in the following subsections.

8.3.2.1 Chromium. The federal drinking water standard for chromium (total chromium) is 100µg/L. Drinking water standards are based on unfiltered concentrations; however, differences in well construction and pumping rates make it difficult to evaluate concentrations of metals when the metals are present as particulate matter and in a dissolved state. In the hexavalent form, chromium is present in an anionic state (CrO_4^{2-}) and is relatively mobile in groundwater. Unfiltered samples may contain metals present as particulate matter, while filtered samples are representative of the more mobile dissolved metals. Filtered samples also may contain some colloidal particles fine enough to pass through the filter. Both filtered and unfiltered samples were collected for chromium and other metals from many of the wells. In general, filtered samples provide the best indication of groundwater contamination levels for chromium, since unfiltered samples are subject to greater variability introduced by the sampling process.

Generally, chromium data show decreasing or flat concentration trends in the majority of the deep-perched water wells. The highest concentrations have occurred in wells proximal to the Warm Waste Pond, as shown in Figure 12. These wells had reported values as high as 800 µg/L during the 1993 to 1995 period. Sample results have not exceeded the MCL (100µg/L) since April 2001 (Figure 12). Exceptions to the downward trend include USGS-069 where concentrations have increased from 2 µg/L (1993) to 14 µg/L (1999–2002), which is still below the MCL (Figure 7-13 in Appendix G). Deep perched wells distal to the Warm Waste Pond have been below the MCL since 1995, and all have shown a general decrease in chromium with the exception of USGS-068, which has shown erratic concentrations around 50 µg/L since 1999 (Figure 7-14 Appendix G). The concentration data in USGS-053 and USGS-056 abruptly end in Figure 12, because these wells have been sporadically dry in recent years. The lining of the evaporation pond and the resultant decrease in infiltration might have caused the drying out of USGS-053 and USGS-056, which are to the southwest and northwest of the Warm Waste Pond. The spike in chromium concentrations in USGS-053 in 1995 does not have a clear explanation. Precipitation was above normal for that year (13.38 in. of rain and 1.64 in. of snow); perhaps the combination of a wet year and the lining of the pond 2 years earlier created a new flow pathway carrying higher concentrations of chromium to this well.